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A CRITICAL REVIEW OF BASE-MAP PROGRAMS AS AN AID TO DEVELOPMENT PROJECTS

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A.1.

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1. Mankind has always required maps, and on too few occasions have maps been available when needed. The need for maps was demonstrated when the first thinking aborigine squatted on his hunkers, and with a finger, traced a sketch in the sand to show friends an easy pass through mountains or the location of a good hunting area. The probabilities are that such maps were fairly accurate considering that the units of measurement were a days walk, or a weeks float on a raft down stream.

2. While one may assume that the specific features which this early cartographer drew were in reasonably correct relative position, it is also a safe guess that there were many blank spaces, or holidays, in his map. In addition to lack of detail or completeness, poor orientation, and variable scales, this first map had three serious deficiencies: 1) it was unique; 2) it was perishable; and 3) it was non-transportable.

3. As time passed and knowledge increased, so did the quality of maps. At the time of the great civilizations around the Mediterrean Sea the knowledge of astronomy, mathematics and writing had developed to a degree that permitted and encouraged great improvements in cartography. Man now had the means of establishing azimuth, or direction, from the stars; had more stable units of distance; and could write and draw on clay tablets or parchment. Furthermore increases in the density of population with attendant government control increased the need for maps, especially to describe property. However the maps of that day still retained one of the original serious disadvantages, that of uniqueness.

4. In fact, although man's ability to compile and draw maps improved greatly, it was necessary to wait hundreds of years for the development of printing presses to overcome the handicap of uniqueness, and be able to prepare maps in quantity from original drawings. Today's multicolor high-speed offset press produces thousands of maps in an hour. So, from the two tools of our first cartographer, memory and a finger, we have come to the point where astronomy, gravity measurements, mathematics, electronics, aviation, photography and photolithography are integrated in the preparation of maps for the benefit of civilization.

5. In the title of this paper, the word critical was used. It was used because of the opinion that makers of policy in development projects underrate the value of maps, are shortsighted in failure to budget for maps, and often neglect to obtain expert advice on what kind of map is needed,

and how to get it. Today many techniques for preparing maps are available. The value of maps in development programs has been demonstrated many times over. In spite of this we encounter opposition to, or at least hesitance, to supply funds for mapping projects in advance of resource studies and construction. In actual fact the United States is pouring millions of dollars into long range development projects, in many cases without the basic maps and resource studies that should be made in advance of investment. One conclusion only can be drawn from this. Officials really do not understand and appreciate the value of maps even though striking proofs are available.

6. The Topographic Division of the United States Geological Survey recently completed a nation-wide survey of map use. It was on a cross section or sampling basis, but broad enough to have validity. Hundreds of interviews were made, and hundreds of replies to questionaires were analyzed. Among the resultant findings one of importance is: Availability of topographic maps in advance of planning of large construction projects can result in savings as high as 3% of the total construction cost. The following example is what this means in dollars. A dam for irrigation, improvement of navigation, or power generation may cost one hundred million dollars. Three percent of this, or 3 million dollars, could be saved if adequate topographic maps were available in advance of planning and construction. Or, looking at it differently, the project could afford as much as 3 million dollars for basic mapping. The cost might be well below that figure. The important consideration here is that the maps procured for this amount will continue to save money and time for subsequent projects in the area mapped.

7. In building a section of major highway in Kentucky, map availability permitted saving enough to pay for one mile of super-highway, no inconsiderable sum. Many states in the United States have such keen appreciation for the need of maps that they supply half the funds required for preparing statewide coverage of standard quandrangle maps. Only recently Ohio entered into a cooperative program of modernizing its maps and half of the state's share was furnished from highway funds. Ohio recognized that the money was well spent in view of their extensive highway program. Quadrangle maps on a scale of 1:24,000, have been used successfully in preparing construction cost estimates and in lieu of preliminary surveys, and such savings may be repeated over and over again.

8. The geologists of the world are probably our most enthusiastic map users. Dealing as they do with many things only partly seen, they fully appreciate the three dimensional geometry afforded by the topographic map. The strike of a rock formation is easily determined by connecting plotted locations of two or more outcrops of the same formation, and dip may be computed from three plotted positions of a formation outcropping at different altitudes. The volume of mineral reserves can be established with a minimum of field work when adequate topographic maps are at hand. Geologists always ask for a map when beginning a study, ask for aerial photos to use in the field, and require a map for the presentation of the study.

9. The United Nations has recognized the value of maps to developing nations in a forceful introduction to its publication on World Cartography; by its organization of a Cartographic Division; in its sponsorship of many regional conferences on Cartography; and in its aid to training selected candidates from developing nations in special cartographic schools.

10. A correlation between the need for and value of maps in national development is shown by the fact that all highly industrialized nations are well mapped, and have a continuing program of revising or remapping at larger scales. Examples are England, France, Germany, Holland, Japan, and Switzerland. This acceptance of the need for maps, and the need for continual updating of existing maps is the best argument for the position that development would have been better managed and with fewer mistakes if mapping had preceeded it. It is this realization of need that caused such nations to put mapping at the head of activities to be undertaken in support of development.

11. Space does not provide for a voluminous listing of the great examples of waste which have been caused by lack of maps, and probably many will never be known, but a few examples will show their magnitude: 1) The huge irrigation dam so located in relation to the land to be irrigated that only the top 2 meters of stored water could be drawn off. 2) Damaging washouts and grade erosion of expensive highways built with inadequate facilities to handle flood water because the area of drainage basins was unknown. 3) The construction of costly mineral reduction facilities where necessary water and power proved impossible to provide, or where transport of materials was uneconomical because of distances and grades. I believe that a careful recording of such errors would show that the money so wasted would more than pay for reconnaissance mapping of the remaining unmapped land areas of the world.

12. The variety of base-map and map-substitute material which can be obtained is considerable. The selection of the optimum material is a technical problem best solved by conference between map user and map maker. To simplify presentation in this paper the types of maps needed for development planning are divided into four categories: 1) engineering topographic; 2) standard topographic; 3) reconnaissance; and 4) regional planning.

13. In the first group are placed all topographic contour maps at scales of 1:5,000 or larger, especially those maps designed and used in the construction of dams, power plants and industrial complexes. Such maps, with extremely high horizontal and vertical accuracy can cost many hundreds of dollars per square kilometer. This is caused by the required density of both horizontal and vertical control, the greater number of photographs, the map content and detail, and the need for extremely high relative accuracy. They are not needed for extensive areas and usually are obtained only when actual construction is assured. The engineering map is, of course, a must in the detailed planning, cost estimating and actual construction so its cost is always charged against construction.

14. In the second group (standard topographic) are placed maps at scales of 1:10,000 to 1:50,000. These are of coordinated quadrangle series type on scales ranging from 1:25,000 to 1:50,000 with contour intervals of 5 to 10 feet and accuracy on the order of the standard series of the United States, England, etc. Costs of this type of map vary considerably, depending on location, type of terrain vegetal cover and density of culture but a round figure of $00 per square kilometer (exclusive of primary geodetic control) can be used. Procurement of complete coverage of these maps in advance is advisable, but in view of the cost and time required for preparation, it is generally recommended that this type of mapping be performed only where earlier studies indicate an over-riding need. In the United States, as of 1960, the time interval required, from initiating contracts for photography to publication, was between 3-1/2 and 5 years. Obviously where the lead

time for the mapping is slight, or non-existant, it is foolhardy to begin such a program concurrently with the collection of data on mineral resources, water, soils, etc.

15. The third category, reconnaissance, includes the number of less accurate and less expensive products such as mosaics, controlled or uncontrolled, and planimetric maps or topographic maps in the 1:100,000 - 1:250,000-scale range. They are based on geodetic control which provides reasonable relative accuracy but not necessarily high absolute accuracy. Another advantage of these types of maps, for use in undeveloped areas, is the speed with which they can be compiled. The reconnaissance type product therefore appears the best solution to the map problems of the under-developed area. While costs vary with size and location of the area it is a safe assumption that small-scale photography (1:70,000) suitable for mosaic or map compilation, and by way of enlargements, for use in the field, will not cost more than $2 per square kilometer. Hiran electronic control suitable for holding extensive areas in relatively good horizontal position should not be more than $3 per square kilometer. Controlled mosaics at 1:50,000-scale might be made from these photographs at a cost not exceeding $2 per square kilometer. Reconnaissance topographic maps at 1:100,000-scale with 25 meter contours can be made of selected areas using the horizontal control developed for the mosaics. Costs will vary through a considerable range depending on local labor costs but in no case should exceed $6 per square kilometer.

16. The fourth and last category contains the regional or planning maps. Usually at 1:500,000 or the millionth-scale, they are useful in presenting overall relationships. This type of map is now generally available throughout the world. It is rarely the direct product of original surveys. This type of map was originally based on astronomic fixes, explorer's notes and sketches, and the earlier geographic attempts of small political entities. During the second World War there was a mammo th effort made to revise or compile such maps directly from aerial photography. In fact, the Trimetrogon system of 3-camera photography and compilation was designed with this in mind. Now such small-scale maps are more likely made by reducing and combining large-scale maps.

17. A coordinated mapping plan for a large under-developed, unmapped area should involve some or all of the following steps: 1) aerial photography; 2) geodetic control; 3) preparation of preliminary or reconnaissance maps; 4) preparation of a coordinated topographic map series (when and where needed); 5) preparation of engineering maps for design and construction.

18. After considering the cost of aerial photography, control, reconnaissance type and engineering maps, how can we choose between them? Perhaps the following criteria will help: 1) The selection must be between standard accuracy and expediency. A reconnaissance map in hand is worth ten standard maps in the making. One justifiably deplores the construction of maps with content or accuracy below those required for a map that will be adequate, except for revision of culture, for many years but we must recognize the urgency of providing earth scientists with adequate map bases upon which they can work today. There is a large area of misunderstanding between map users and map makers regarding accuracy and content. The geologist and the soil scientist require many identifiable positions with relative accuracy of position of 50 to 100 feet, and of elevation to 50 feet. The map maker usually translates these requirements in terms of absolute position and elevation on the earth's surface with the result that costs and preparation

time skyrocket because of the needed control. It should be remembered that a map with high relative accuracy can be produced much more cheaply than one with high absolute accuracy. 2) The time available. Mapping a large area by classic ground methods requires a large force and many months of field work. Aerial photography is a must but even in this rapid phase timing is important. In many areas weather is so critical a factor that a few days lost might cause a years wait for good photographic weather. Use of electronics is speeding up the control phase but in this area also there is a choice. Airborn equipment is adequate for reconnaissance-type maps but slower moving ground equipment is still needed for the standard-type maps.

19. It is most probable that problems concerned with soils, water, land use and mineral resources will be screaming for attention immediately. If this is the case, then aerial photographs will be required at once. Aerial photographs are the best and most rapid collectors of earth-surface data known today. They are probably, on a unit basis, the cheapest. In addition to being a permanent record, and one from which data can be recovered quickly and transferred to other media, they serve as the best media for recording field observations. Owing to recent improvements in aerial camera lenses it is now possible to photograph large areas economically at scales between 1:70,000 and 1:100,000, obtaining at one time photographs lending themselves to reconnaissance mapping and also to enlargement to the vicinity of 1:20,000-scale for photointerpretation, and use in the field.

20. With careful planning the amount and type of control needed for the mapping can be obtained at the same time as photography. Actually some types of airborn electronic equipment such as Shoran and APR are designed to be used in the photographic airplane.

21. Lack of basic data can, and has resulted in wrong assumptions, leading in turn to expensive errors in planning. Therefore it is the thesis of this paper that all of the mapping tools are at hand for our use in development programs. All that is now required is the decision to apply them. Adequate maps should be available in advance for use in the fields of geology, hydrology, soils, agriculture, forestry, transportation, resettlement, etc. It is also recommended that the reconnaissance type map comes closest in terms of overall usefulness, cost, and time available for preparation. Considering the savings in construction costs plus additional savings in resource surveys, at least the first 5% of funds alloted to development projects should be assigned for aerial photography and mapping. These recommendations are made with the knowledge that both industrial and agricultural development must be founded on accurate data about availability of raw materials, power, transportation, markets, extent and type of soils, rainfall, stream flow, and groundwater. They are made in the knowledge that impact programs are usually considered more important and in spite of the pressure for immediate programs to feed and care for hungry, ill and illiterate peoples.

22. Finally, let us consider capacity for map preparation. It is no paradox that less developed countries are the poorest mapped. They usually have fewer persons educated in mapping who are capable of designing, planning and directing a mapping program; and less financial backing for purchase of required equipment. On the other side of the coin they usually have an intense desire and national pride in doing such things themselves. Organizing, training and equipping a national organization may well take more years than are available. It appears clear, therefore, that the best and most rapid method for obtaining necessary photographs and maps is by use of well established

government agencies, commercial firms, or combinations of the two. Every effort should be made to introduce nationals of the country into all operations but this training aspect should not be allowed to delay delivery of the basic maps.

23. The extremely under-developed area in the Northeast of Brazil is presented as an example of how to proceed in a program such as this. It is practically unmapped; about one-half is covered with photographs at scales making map compilation expensive; it has a skeleton of primary horizontal and vertical control over about two-thirds its area; studies in the minerals, irrigation, ground and surface water and soils use fields have already started; it is large (almost 2 million square kilometers); it does not have good ground transport; there is illiteracy, hunger and illness there; a dynamic improvement is needed in less than 5 years.

24. The Superintendency of the Development of the Northeast (SUDENE) and United States Agency for International Development, Brazil (USAID/Brazil) are negotiating the following 5-year mapping plan, which is estimated at 7.2 million dollars - somewhat less than 3% of the joint funds earmarked for development in that area.

25. The plan contains the following main targets which can readily be identified with recommendations in this paper. They are: 1) obtain complete photo coverage at 1:70,000-scale in 4 years; 2) provide Hiran control for the uncontrolled portion of the area; 3) prepare controlled mosaics of the whole area; and 4) prepare 1:100,000-scale topographic map-manuscript over a selected one-third area.

26. The photography and Hiran control will be obtained on contract. The preparation of mosaics and maps will be partly by contract and partly by using existing Brazilian government facilities where training programs are already underway. The mapping will probably be performed in the same manner.

27. The scientists and technicians involved in the efforts depending on maps for basic data are firm in the conviction that this mapping program, if carried through, will expedite their work and contribute to the accuracy of the decisions made, as well as provide many economies in their operations.

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